



Physical Rehabilitation in Lower Extremity Wound Healing

Incorporating this therapy can lead to better outcomes.

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Introduction

Physical medicine is an essential component of recovery from numerous medical and surgical conditions. Although an essential component of most musculoskeletal recovery plans, wound healing physical rehabilitation is often an afterthought, relegated to crutch training for offloading and occasionally manual lymph drainage in the special condition of lymphedema.

The purpose of this article is to show how many physical rehabilitation interventions can be beneficial in treating chronic wounds and to show how to apply this knowledge in the development of a treatment protocol for patients who suffer from chronic wounds with rehabilitation.

In some countries, physical medicine specialists are an integral part of the wound care team, and physical rehabilitation is used as a first line therapy for chronic lower extremity wounds.¹⁶ In the United States, the essential parts of a wound healing plan are administered primarily by physicians in concert with nurses. They are focused on managing the systemic components leading to poor healing, and then choosing which dressing or advanced therapy will increase healing efficiency. Physical and occupational therapies are most often used to manage disabilities or environmental factors affecting the wounded patient, etiologies secondary to the wound, rather than direct wound care itself.¹⁶

The best rehabilitation program for each patient should be determined

by a physical or occupational rehabilitation specialist in cooperation with the patient's referring physician. The wound care itself is only part of a larger multidisciplinary treatment effort that is often poorly coordinated unless occurring in a larger university setting where multiple interacting specialties are geographically near one another.

Rehabilitation programs are routine for certain specialties, such as ortho-

for the wound to closure, leaving out the rehabilitation component or applying it as an afterthought. To construct a reason for referral, clinicians must reach outside their area of expertise to find a reimbursable reason for adding rehabilitation to the mix. For instance, gait training and therapeutic exercise are not covered services when provided by most wound care specialists and should be referred out but often are

Rehabilitation programs are routine for certain specialties, such as orthopedics, where predictable and measurable outcomes are common.

pedics, where predictable and measurable outcomes are common. Given the high variability, unique nature, and inconsistent timeline of wound care, wound healing is less likely to fit into such a model. Currently, many of the interventions employed in the rehabilitation of the wounded patient are poorly reimbursed or denied when the primary diagnosis is a wound. Contributory conditions such as edema, muscle weakness, skeletal contractures, gait abnormalities, or balance disturbances are commonly found in patients with chronic wounds. These conditions must be recognized by the primary clinician and individually addressed in the construction of a wound care plan.

This unfortunately is not what happens. A single specialist often cares

not. Zhou, et al. demonstrated that incorporation of physical rehabilitation in a program for chronic wound patients was beneficial in reducing both healing time and cost.²⁹

There are several primary etiologies leading to integumentary failure in the lower extremity. Each one has aspects that can be addressed by a rehabilitation specialist to improve healing and reduce healing time. Trauma can occur as instantaneously applied direct force, intermittently applied cumulative direct force, or indirect shear forces resulting in injury to the skin and subcutaneous tissues. When this occurs in the presence of an intact nervous system, the person normally reacts reflexively to protect the injured tissue, thereby

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removing the offending force.

Rehabilitation can provide gait training, off-loading interventions, strengthening stretching and proprioceptive training, bracing, and home environmental consultation to reduce future injury. In the second etiology, protection by the perception of pain is absent due to neuropathy. Compensatory gait training, offloading interventions such as position awareness or bracing, and even training in the use of newer load monitoring devices can be aided by referral to physical medicine.

A lack of arterial, venous, or lymphatic support makes up the primary reason for our third etiology resulting in an inadequate delivery of essential supplies of oxygen and cellular repair signals, as well as an inadequate removal of inflammatory byproducts, necrotic, and infectious debris hindering the healing process. Lymphatic blockade due to several primary and secondary causes is attracting more interest in the management of lower extremity wounds. The most common cause for lower extremity secondary lymphedema is phlebolymphe­dema, a secondary condition stemming from repetitive inflammation leading to the blockage of normal lymphatic flow.

Many of the patients we see for diabetic, venous, or traumatic (post-operative) wounds have a level of lymphedema that should be addressed but is not. Restriction of lymphatic flow produces an accumulation of waste and fluid in the limb and a stalling of the normal healing process. Lymphatic therapy by a certified lymphedema therapist (CLT) would help reduce drainage, edema, and an unnecessary prolongation of healing. Training in self-administration of lymphatic drainage techniques, application and training in segmental compression device use, and training in donning and doffing of compression hose are best administered by a trained therapist. Access to necessary nutritional or occupational counseling, physical exercise programs designed for a patient's specific deficit, and positive emotional support to help patients cope with and recover from disability associated with a chronic wound are all components of a good rehabilitation plan.

Peripheral Neuropathy

Peripheral neuropathy manifests as a loss of protective sensation to stimuli such as pain or extreme temperature, sensations such as numbness, tingling, burning or pain, and foot deformities such as hallux valgus, claw toes, or in the extreme, Charcot's arthropathy.²⁵ A lack of protective sensation coupled with unrecognized repetitive stress creates a condition where tissue breakdown is likely.² In patients with foot ulcers, the probability of having peripheral neuropathy is over 80%.²⁵ The pathophysiology of neuropathy is one of the main culprits for the development of non-healing lower extremity wounds. Testing for early clinical signs of neuropathy is usually relegated to the use of a 5.07-size (10 gram) monofilament indicating a

the importance of a multidisciplinary approach.³ A focused study by Cruccu, et al. examined neurostimulation in the treatment of neuropathic pain. This study utilizes transcutaneous electrical nerve stimulation (TENS) and suggests superior outcomes in patients treated with TENS compared to the placebo.⁸ TENS uses external stimulation and training by a rehabilitation specialist to mask an underlying or distal painful sensation.³ TENS may reduce wound and periwound pain and, depending on the type and wave form utilized, alters the skin battery, or wound electrical potential, and improves wound healing as well.²⁰

Exercise has many benefits for both body and mind. It may also be able to help with neuropathy. In a randomized controlled trial of 87 patients

The three most common risk factors for developing PAD include diabetes mellitus, smoking cigarettes, and advanced age over 50 years old.

loss of protective sensation (LOPS).²⁵ A more sensible test would be to screen with the smaller 4.56 (4 gram) or 4.08 (1 gram) monofilaments indicating an impending LOPS, a condition that can be addressed with a referral to a nutrition therapist for a change in diet and lifestyle, much easier to employ than the rather ineffective treatments after sensation is gone.

Proprioceptive testing is less often done and may be the key to the patient learning safer gaits and being made aware, through training by a trained physical therapist, of harmful positions and pressure-producing situations that lead to ulcers on the foot. Given the complex pathogenesis of neuropathy, a definitive treatment to reverse the loss, except for limited success with some nutraceuticals, remains elusive. Protective therapies and lifestyle changes best administered by a rehab specialist are the best way to motivate patients to make the changes necessary to protect themselves.

A review by Bernetti, et al. suggests that physical rehabilitation should be included in the treatment plan for neuropathy and emphasizes

by Dixit, et al. moderate intensity aerobic exercise was demonstrated to improve peroneal nerve conduction velocity, sural sensory nerve conduction velocity, and the Michigan Diabetic Neuropathy Score (MDNS).¹⁰

Peripheral Arterial Disease (PAD)

Chronic wounds are known to be associated with an increased risk of cardiovascular events. The three most common risk factors for developing PAD include diabetes mellitus, smoking cigarettes, and advanced age over 50 years old.¹⁶ Patients with PAD demonstrate greater mobility loss and more functional impairments, and typically perform less physical activity.¹⁶ This reduced vascular supply to the lower extremity in correlation with lack of mobility are key components of the formation and recurrence of chronic diabetic foot ulcers.² Early vascular assessment and revascularization are important elements in the treatment of lower extremity wounds. However, many patients with diabetic comorbidities are poor healers and are not good candidates for vascular procedures. In these cases, a rehabilitation

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specialist can administer conservative treatments to increase vascularity and help avoid amputation.²

Supervised treadmill walking was shown to be effective in treating claudicatory symptoms in patients with PAD.¹⁶ By increasing the ability of patients to exercise, blood flow to the lower extremity is increased, promoting tissue vascularity and healing. It remains unclear whether patients who experience ischemic leg pain while walking should exercise to maximum pain or rest at the start of symptoms; however, the most recent randomized trial suggests that in either case, the benefits of walking to treat PAD are

fore cannot walk easily or patients who require the use of a wheelchair who cannot participate in treadmill walking.

Ischemia due to atherosclerosis of arteries is prevalent in 1-7% of the population above 60 years of age. Ischemia can lead to intermittent claudication and, in more severe cases, limb-threatening necrotic changes of peripheral tissues.²⁷ The use of various forms of intermittent pneumatic compression (IPC) applied in a particular manner was found to significantly increase blood flow in patients with ischemia. Most of us are familiar with the use of intermittent compression designed to improve arterial flow and encourage arteriogenesis over time. IPC is an asynchronous compression

A therapy similar to IPC, Remote Ischemic Conditioning (RIC), uses a standard blood pressure cuff to induce episodes of ischemia for 3-5 minutes.⁴ This treatment aims to lower costs by using a blood pressure cuff instead of a specialized cuff like with IPC. The ischemia induced by RIC facilitates distress signals that cause a decrease in the inflammatory markers TNF- α and IL-1B.⁴ In addition to proinflammatory markers, neutrophils, and neutrophil-platelet complexes were noted to decrease, and anti-inflammatory markers have been shown to increase. Shaked, et al. evaluated diabetic foot ulcer healing utilizing RIC when compared to a control group using standard of care management.²³ Their results revealed that the group using RIC had significantly smaller ulcers at the end of the study period compared to the control group. Both of these therapies may promote angiogenesis in ischemic areas, can be administered by physical therapists, and may be a useful adjunct to chronic wound management.

When walking ability is significantly impaired or contraindicated, the use of electrostimulation (ES) therapy can be utilized for treatment of PAD.¹²

consistent despite when breaks are taken due to pain.¹⁶ Even PAD patients who do not experience claudicatory symptoms still showed significant improvement in both walking performance and 6-minute walk distance.¹⁶ Based on this study, patients with PAD and chronic wounds that do not impair their ability to walk or engage in aerobic lower extremity exercise with minimal weight-bearing in the case of plantar wounds, may benefit from a supervised walking program to improve vascularity.

When walking ability is significantly impaired or contraindicated, the use of electrostimulation (ES) therapy can be utilized for treatment of PAD.¹² Varying frequencies from 1-259 Hz have been used for treatment.¹² ES was determined to significantly increase walking capacity in patients with intermittent claudication who also had diabetes.¹²

Houghton published a review of over 62 clinical research studies and 22 well-designed randomized clinical trials that provide strong support for the use of EST on various types of chronic wounds and pressure ulcers in particular.¹⁴ This therapy can be useful for patients with plantar wounds who there-

device applied as a home therapy.⁹ A larger, clinic-centered device was developed previously that uses cardiosynchronous compressions timed by your own ECG to go off every 2-3 beats during diastole to facilitate venous expulsion from the limb and allow for unimpeded improved arterial inflow which was also found to induce arteriogenesis over time.²⁶

A technique called intermittent pneumatic compression, or IPC, that requires specialized compression equipment consists of obstructing venous flow by inflating two 10-centimeter wide cuffs, one at the forefoot and one at the calf, to 120 mmHg for 5-6 seconds, and then deflating them slowly over a period of 16 seconds repeatedly for a total time of 45-60 minutes per day.²⁷ Improvement was measured by the toe capillary refill time and pain free walking distance time. Unfortunately, there was an increase in toe brachial index of, on average, at least 50% after two years of treatment. IPC could be beneficial to patients with chronic distal foot ulcers; however, consistent, daily compliance for 2 years was a major drawback to IPC treatment. Insurance coverage for off-label use of IPC is also non-existent.

Physical Exercise

Pence, et al. confirmed that exercise and physical activity improve healing rates in a review of both human and animal studies and that obesity, a major cause of secondary lymphedema and a common finding in diabetics, can also be reduced.¹⁹ A study comparing physical activity's effects on revascularization of tissues was conducted by Sashwati, et al.²² They found physical exercise can result in the increased formation of H₂O₂, and other reactive oxygen species (ROS), a state that mimics that which occurs during normal wound healing, encouraging revascularization during the healing process. Physical exercise also prompts the formation of capillary networks and angiogenesis, causing increased vascularity and oxygen perfusion within the tissue.

A study carried out by Ohio State University aimed to test whether exercise can increase the rate of wound healing. To accomplish this, they created identical wounds on the arms of participants and divided them into an exercise group and a non-exercise group. The exercise group's wounds healed on average 10 days faster, or up

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to 25% faster than the control group's.¹⁸ Specific exercises were determined to be extremely beneficial for patients suffering from pressure wounds. The addition of a rehabilitation specialist would assure that patients get a structured and supervised exercise program designed to maximize wound healing potential. A physical therapist would be able to determine what exercises may be substituted or added to this regimen especially for wounds located in areas like the feet and lower legs where weight-bearing is an issue.

Lymphedema and Venous Insufficiency

Lymphatic impairment from any cause creates localized or regional lymphatic immunopathy when the normal immune function of the wound bed and periwound tissues is impeded. A lymphatic blockade from either physical restriction of lymph flow or fibrosis of periwound tissues due to repetitive inflammatory stimulus causes proteins to escape with normal vasodilation in response to the presence of a wound. This leads to cutaneous regions of skin barrier failure, rendering the skin more susceptible to breakdown in the case of venous leg ulcer formation and the prevention of healing in chronic wounds.⁵

All lower extremity edema is lymphatic overload from one factor or another. Elevation, rhythmic contraction of lower extremity muscles, and deep diaphragmatic breathing can produce considerable decongestive drainage of the lower extremity for patients with lymphedema or phlebolymphe-
dema secondary to venous insufficiency. It is recommended by the National Lymphedema Network <https://lymphnet.org/> that patients be referred to a certified lymphedema therapist CLT for both training in home care activities as well as complete decongestive therapy CDT to aid in reduction of edema and, as we have seen, healing of lower extremity wounds.

When patients do not have access to a CLT for lymphedema, the use of diaphragmatic breathing exercises is a valuable tool in facilitating the movement of lymph through the deep lymphatic structures, including lumbar and pelvic lymph nodes, to the thoracic duct where fluid re-enters the circulation. Deep-breathing exercises and self-massage as part of a daily exercise routine can be taught to wound patients and should improve their lymphedema status.¹¹

Compression therapy administered as an integral part of a physical therapy program plays a pivotal role in the treatment of venous leg ulcers. Although less common in lymphedema management, new findings indicate that segmental devices specifically designed to move lymph fluid can be effective in both venous and lymphatic disease.²⁸ The arterial improvement seen with intermittent compression, along with the reduction in both venous and lymphedema, lead us to question whether incorporating these compression therapies for diabetic ulcers in patients with secondary lymphedema from a number of causes might not significantly improve healing. Improvement in lymph circulation with manual lymph drainage (MLD) as a part of complex decongestive physiotherapy (CDP) has been shown to improve ulcer healing in a study by Szolnoky when compared to standard compression therapy.²⁴

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Emotional Support

Diabetes and the disability of having a wound leads to social isolation, deterioration in marital life and family relationships. These problems increase over time, which, in turn, cause a vicious circle of increasing depression. In patients who suffer with chronic wounds, inactivity delays wound healing, promotes a feeling of helplessness, and contributes to depression in an already depressed population.¹³ Exercise in a regularly administered physical therapy program designed to enhance wound healing is an intervention that has shown great promise in alleviating symptoms of depression.⁷

Discussion

A rehabilitation plan should be included in most, if not all, wound healing plans. The nature of rehabilitation in the wounded population is often complicated based on their many co-morbidities and restrictions. A specially trained rehabilitation specialist is the best person to develop that plan in consultation with the various other specialists involved in the patient's care. A carefully developed rehabilitation plan should include not only the type, frequency, and duration of the exercise or modality but the goals of therapy and specific safety precautions such as joint range of motion limitations, weight-bearing limitations, and comorbid conditions that impact therapy limitations. Exercise prescriptions must be appropriate for each patient, and given their complexity, they should be designed by trained rehabilitation specialists. **PM**

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